SPRUCE Environmental Monitoring Data: 2010-2011

Summary:

This data set reports selected ambient environmental monitoring data from the S1 bog for the period June 2010 through October 2011. There are three monitoring sites located in the bog: Stations 1 and 2 are co-located at the southern end of the bog and Station 3 is located north central and adjacent to an existing U.S. Forest Service monitoring well. Figure 1.

The stations are equipped with standard sensors for measuring meteorological parameters, solar radiation, soil temperature and moisture, and groundwater temperature and elevation. Note that some sensor locations are relative to nearby vegetation and bog microtopographic features (i.e., hollows and hummocks). See Table 1 for a list of measurements. Sensors and data loggers were installed and became operational in June, July, and August 2010.

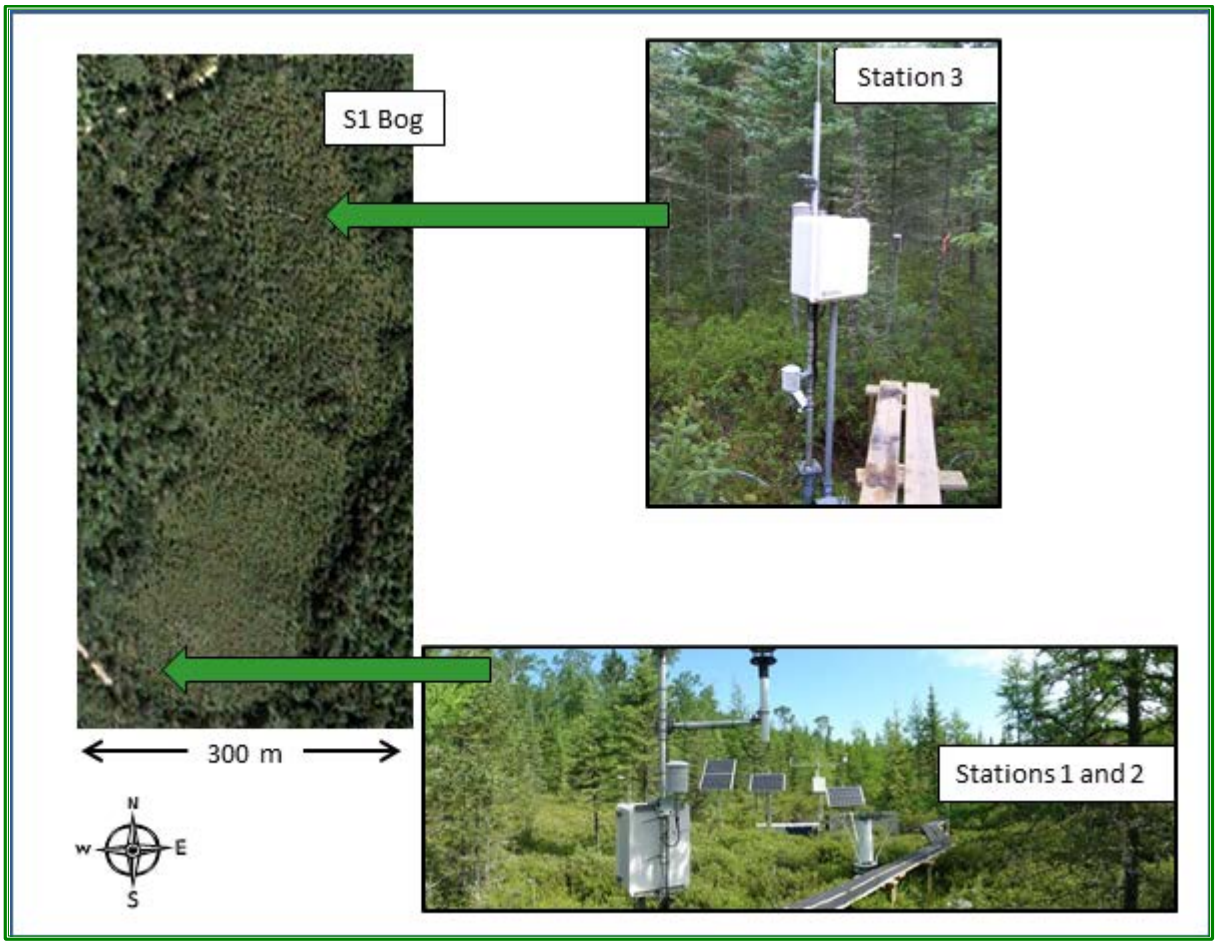

Figure 1. Locations of environmental monitoring stations in the S1 Bog. Photo of Stations 1 (in background) and 2 (EM1 and EM2) taken looking north. Photo of Station 3 (EM3) taken looking east.

Additional parameters collected over this time range will be added to this data set as calibration and quality checks are completed. More sensors were added in September 2011 and they will be included after their performance has been assessed.

The site is the 8.1-ha S1 bog, a *Picea mariana* [black spruce] – Sphagnum spp. ombrotrophic bog forest in northern Minnesota, 40 km north of Grand Rapids, in the USDA Forest Service Marcell Experimental Forest (MEF). The S1 bog was harvested in successive strip cuts in 1969 and 1974 and the cut areas were allowed to naturally regenerate. Stations 1 and 2 are located in a 1974 strip that is characterized by a medium density of 3-5 meter black spruce and larch trees with an open canopy. The area was suitable for siting a monitoring station for representative meteorological conditions on the S1 bog. Station 3 is located in a 1969 harvest strip that is characterized by a higher density of 3-5 meter black spruce and larch trees with a generally closed canopy. Measurements at this station represent conditions in the surrounding stand.

Table 1. Measurements at each Environmental Monitoring Station and the position of the respective sensors.

General Parameters	Station 1	Station 2	Station 3	Sensor Position(s)
Air temperature	X	X	X	Surface, 1, and 2 meters
Relative humidity	X	X	X	Surface and 2 meters
Atmospheric pressure	X	X		1 meter
Dewpoint temperature	X	X		2 meters
Wind speed	X	X		2 meters
Wind direction	X	X		2 meters
Precipitation total	X			2 meters
Photosynthetically active radiation (PAR, 400-700 nm)	X	X	X	2 meters
Photosynthetically active radiation (PAR, 400-700 nm)	X	*		Under and around vegetation
Albedo	X			2 meters
Net radiation	X			2 meters
Total diffuse irradiance	*			2 meters
Total global irradiance	*			2 meters
Shortwave downwelling irradiance (300-2800 nm)	X			2 meters
Shortwave upwelling irradiance (300-2800 nm)	X			2 meters

General Parameters	Station 1	Station 2	Station 3	Sensor Position(s)
Shortwave net radiation (300-2800 nm)	X			2 meters
Longwave downwelling irradiance (4500-42000 nm)	X			2 meters
Longwave upwelling irradiance (4500-42000 nm)	X			2 meters
Longwave net radiation (4500-42000 nm)	X			2 meters
NDVI	*			2 meters
Groundwater temperature	X	X	X	Monitoring well
Groundwater level	X	X	X	Monitoring well
Soil temperature	X	X	X	Multiple depths from surface of hummocks and hollows to 200 cm
Volumetric water content	X		X	Multiple depths from surface to 20 cm
***Recent additions, September 2011. Will be included in future data sets.**				

SPRUCE Project Description

The SPRUCE (Spruce and Peatland Responses Under Climatic and Environmental Change) is an experiment to assess the response of northern peatland ecosystems to increases in temperature and exposures to elevated atmospheric CO2 concentrations. It is the primary component of the Terrestrial Ecosystem Science Scientific Focus Area of ORNL's Climate Change Program, focused on terrestrial ecosystems and the mechanisms that underlie their responses to climatic change. The experimental work is to be conducted in a *Picea mariana* [black spruce] – Sphagnum spp. bog forest in northern Minnesota, 40 km north of Grand Rapids, in the USDA Forest Service Marcell Experimental Forest (MEF). The site is located at the southern margin of the boreal peatland forest. It is an ecosystem considered especially vulnerable to climate change, and anticipated to be near its tipping point with respect to climate change. Responses to warming and interactions with increased atmospheric CO2 concentration are anticipated to have important feedbacks on the atmosphere and climate, because of the high carbon stocks harbored by such ecosystems.

Experimental work in the 8.1-ha S1 bog will be a climate change manipulation focusing on the combined responses to multiple levels of warming at ambient or elevated CO2 (eCO2) levels. The experiment provides a platform for testing mechanisms controlling the vulnerability of organisms, biogeochemical processes and ecosystems to climatic change (e.g., thresholds for organism decline or mortality, limitations to regeneration, biogeochemical limitations to productivity, the cycling and release of CO2 and CH4 to the atmosphere).

The manipulation will evaluate the response of the existing biological communities to a range of warming levels from ambient to +9°C, provided via large, modified open-top chambers. The ambient and +9°C warming treatments will also be conducted at eCO2 (in the range of 800 to 900 ppm). Both direct and indirect effects of these experimental perturbations will be analyzed to develop and refine models needed for full Earth system analyses.

Marcell Experimental Forest

Streamflow, weather, and well data collection began on the Marcell Experimental Forest in 1960. This 898-ha site has six calibrated watersheds, each consisting of a mineral soil upland and organic soil peatland; an intermittent or perennial stream drains each peatland and its larger watershed. Formally established in 1962, the Marcell contains two units on land owned by the USDA Forest Service, Chippewa National Forest, State of Minnesota, Itasca County, and a private individual. Previous and ongoing research addresses the ecology and hydrology of peatland. Research concerns typical upland/wetland watersheds in the Lake States, atmospheric chemistry, nutrient cycling, soil quality, tree-stand dynamics, and a variety of watershed treatments applied to upland or bogs to investigate impacts on water yield, peak streamflow, water quality and nutrient processing.

SPRUCE Sponsor

Research sponsored by the Office of Biological and Environmental Research within the U.S. Department of Energy's Office of Science.

The SPRUCE experiment is a multi-year cooperative interaction among scientists of the Oak Ridge National Laboratory operated by UT-Battelle, LLC and the U.S. Forest Service, Northern Research Station, Marcell Experimental Forest.

Data and Documentation Access:

Get Data

For public access to SPRUCE data please visit the SPRUCE Web Site: http://mnspruce.ornl.gov/

Description and Links to Companion Files and Supplemental Information

Marcell Experimental Forest Website: /http://www.nrs.fs.fed.us/ef/locations/mn/marcell/

SPRUCE Project Website with plans and additional information: http://mnspruce.ornl.gov/

SPRUCE Data Policy - Sharing, Access, and Use Recommendations:
http://mnspruce.ornl.gov/content/spruce-data-policies

Data Dictionary with complete parameter and sensor descriptions: Link TBD

Related Data Sets:

Phenology Photographs: Coming soon

Data Citation:

Cite this data set as follows:

Hanson, P.J., J.S. Riggs, C. Dorrance, and L.A. Hook. 2011. SPRUCE Environmental Monitoring Data: 2010-2011. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. doi: 10.3334/CDIAC/spruce.001

Table of Contents:

- 1 Data Set Overview
- 2 Data Characteristics
- 3 Applications and Derivation
- 4 Quality Assessment
- 5 Acquisition Materials and Methods
- 6 References
- 7 Data Access

1. Data Set Overview:

This data set reports selected ambient environmental monitoring data from the S1 bog for the period June 2010 through October 2011. There are three monitoring sites located in the bog: Stations 1 and 2 are co-located at the southern end of the bog and Station 3 is located north central and adjacent to an existing U.S. Forest Service monitoring well.

The stations are equipped with standard sensors for measuring meteorological parameters, solar radiation, soil temperature and moisture, and groundwater temperature and elevation. Note that some sensor locations are relative to nearby vegetation and bog microtopographic features (i.e., hollows and hummocks). Sensors and data loggers were installed and became operational in June, July, and August 2010.

Additional parameters collected over this time range will be added to this data set as calibration and quality checks are completed. More sensors were added in September 2011 and they will be included after their performance has been assessed.

The site is the S1 bog, a *Picea mariana* [black spruce] – Sphagnum spp. bog forest in northern Minnesota, 40 km north of Grand Rapids, in the USDA Forest Service Marcell Experimental Forest (MEF).

2. Data Characteristics:

There is one data product with selected results of ambient environmental monitoring in the S1 bog for the period June 2010 through October 2011.

Spatial Coverage

All measurements were made at the 8.1-ha S1 bog forest site in northern Minnesota, 40 km north of Grand Rapids, in the USDA Forest Service Marcell Experimental Forest (MEF). These coordinates are the central location of the S1 bog.

Site boundaries: Latitude and longitude given in decimal degrees.

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (meters amsl)	Geodetic Datum
S1 Bog, Marcell Experimental Forest	-93.48283	-93.48283	47.50285	47.50285	418	WGS84

Temporal Coverage

Sensors and data loggers were installed and became operational in June, July, and August of 2010. Data are reported from the beginning of monitoring through October 2011. The exact date range for each station and parameter varies. There are also periods when data were not collected due to instrument or other equipment failures and removal of sensors to prevent damage (i.e., freezing groundwater).

Time period:

The data set covers the period 2010/07/16 to 2011/11/01.

Data File Description

Each observation in the data file reports the 30 minute average for the parameter or the total precipitation for the 30 minute interval. All of the data are contained in one comma separated (.csv) ASCII file.

These data are considered at **Quality Level 1**. Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures.

The column heading/parameter name indicates (1) at which Environmental Monitoring Station (EM1, EM2, or EM3) the measurement was made and (2) indicates the measurement and the sensor position (e.g., **EM3_PAR_2M**) **or** the special relative location of the sensor (e.g., **EM1_Hollow80cm**). For the latter Column Heading, the Name Description (**Soil temperature**) and the Sensor Position (**80 cm below surface of hollow**) complete the description.

Missing values are represented by -9999.

Data Dictionary:

Column Headings	Units or Format	Name Description	Sensor Position	Sensor Description
date	yyyy-mm-dd	Date of measurement		Data logger
time	hh:mm	Time at beginning of 30 minute measurement / averaging interval. Interval always begins at either hh:00 or hh:30. Time zone is CST.		Data logger
doy	ddd	Day of year starting from January 1. Measurements started on day 170, June 16, 2010.		Data logger
dec_doy	ddd.dddd	Day of year with time as decimal fraction of day.		Data logger
cdoy	ddd	Continuous measurement day (of year) starting from January 1, 2010. Measurements started on day 170, June 16, 2010. Measurement day is reported continuously and was not reset for 2011.		Data logger
dec_cdoy	ddd.dddd	Continuous measurement day (of year) with time as decimal fraction of day.		Data logger
year	yyyy	Year of measurement		Data logger
EM1_AirTC_2M	Deg C	Air Temperature	2 meters above ground level	Platinum Resistance Thermometer
EM1_RH_2M	%	Relative humidity	2 meters above ground level	Capacitive RH sensor
EM1_AirTCHumm	Deg C	Air Temperature	Hummoch surface	Platinum Resistance Thermometer
EM1_RH_Humm	%	Relative humidity	Hummoch surface	Capacitive RH sensor
EM1_BP_kPa	kPa	Atmospheric pressure	1 meter above ground level	Silicon capacitive sensor
EM1_Dewpoint	Deg C	Dewpoint temperature	2 meters above ground level	Calculated
EM1_Dewpoint_Diff	Deg C	Air temperature minus dewpoint temperature	2 meters above ground level	Calculated
EM1_Rain_mm	mm	Precipitation total	2 meters above ground level	Tipping bucket rain gauge

Column Headings	Units or Format	Name Description	Sensor Position	Sensor Description
EM1_WS_ms_S	meters/second	Wind speed	2 meters above ground level	Two-dimensional ultrasonic anemometer
EM1_WindDir_D1	Deg	Wind direction	2 meters above ground level	Two-dimensional ultrasonic anemometer
EM1_WindDir_SD1	Deg	Wind direction, 1 standard deviation	2 meters above ground level	Two-dimensional ultrasonic anemometer
EM2_AirTC_2M	Deg C	Air Temperature	2 meters above ground level	Platinum Resistance Thermometer
EM2_RH_2M	%	Relative humidity	2 meters above ground level	Capacitive RH sensor
EM2_AirTCHumm	Deg C	Air Temperature	Hummoch surface	Platinum Resistance Thermometer
EM2_RH_Humm	%	Relative humidity	Hummoch surface	Capacitive RH sensor
EM2_BP_kPa	kPa	Atmospheric pressure	1 meter above ground level	Silicon capacitive sensor
EM2_WS_ms_S	meters/second	Wind speed	2 meters above ground level	Two-dimensional ultrasonic anemometer
EM2_WindDir_D1	Deg	Wind direction	2 meters above ground level	Two-dimensional ultrasonic anemometer
EM2_WindDir_SD1	Deg	Wind direction, 1 standard deviation	2 meters above ground level	Two-dimensional ultrasonic anemometer
EM3_AirTC_1M	Deg C	Air Temperature	2 meters above ground level	Platinum Resistance Thermometer
EM3_RH_1M	%	Relative humidity	2 meters above ground level	Capacitive RH sensor
EM3_AirTC_2M	Deg C	Air Temperature	1 meter above ground level	Platinum Resistance Thermometer
EM3_RH_2M	%	Relative humidity	1 meter above ground level	Capacitive RH sensor
EM1_HollowSurf	Deg C	Soil temperature	Surface of hollow	Thermocouple - Type T
EM1_Hollow5cm	Deg C	Soil temperature	5 cm below surface of hollow	Thermocouple - Type T
EM1_Hollow20cm	Deg C	Soil temperature	20 cm below surface of hollow	Thermocouple - Type T
EM1_Hollow40cm	Deg C	Soil temperature	40 cm below surface of hollow	Thermocouple - Type T
EM1_Hollow80cm	Deg C	Soil temperature	80 cm below surface of hollow	Thermocouple - Type T
EM1_Hollow160cm	Deg C	Soil temperature	160 cm below surface of hollow	Thermocouple - Type T
EM1_Hollow200cm	Deg C	Soil temperature	200 cm below surface of hollow	Thermocouple - Type T
EM1_Hummock_plus_30cm	Deg C	Soil temperature	Hummock surface, 30 cm above surface of hollow	Thermocouple - Type T
EM1_Hummock_plus_25cm	Deg C	Soil temperature	5 cm below surface of hummock, 25 cm above surface of hollow	Thermocouple - Type T
EM1_Hummock_plus_10cm	Deg C	Soil temperature	20 cm below surface of hummock, 10 cm above surface of hollow	Thermocouple - Type T
EM1_Hummock10cm	Deg C	Soil temperature	40 cm below surface of hummock, 10 cm below surface of hollow	Thermocouple - Type T
EM1_Hummock50cm	Deg C	Soil temperature	80 cm below surface of hummock, 50 cm below surface of hollow	Thermocouple - Type T

Column Headings	Units or Format	Name Description	Sensor Position	Sensor Description
EM1_Hummock130cm	Deg C	Soil temperature	160 cm below surface of hummock, 130 cm below surface of hollow	Thermocouple - Type T
EM1_Hummock170cm	Deg C	Soil temperature	200 cm below surface of hummock, 170 cm below surface of hollow	Thermocouple - Type T
EM2_HollowSurf	Deg C	Soil temperature	Surface of hollow	Thermocouple - Type T
EM2_Hollow5cm	Deg C	Soil temperature	5 cm below surface of hollow	Thermocouple - Type T
EM2_Hollow20cm	Deg C	Soil temperature	20 cm below surface of hollow	Thermocouple - Type T
EM2_Hollow40cm	Deg C	Soil temperature	40 cm below surface of hollow	Thermocouple - Type T
EM2_Hollow80cm	Deg C	Soil temperature	80 cm below surface of hollow	Thermocouple - Type T
EM2_Hollow160cm	Deg C	Soil temperature	160 cm below surface of hollow	Thermocouple - Type T
EM2_Hollow200cm	Deg C	Soil temperature	200 cm below surface of hollow	Thermocouple - Type T
EM2_Hummock_plus_20cm	Deg C	Soil temperature	Hummock surface, 20 cm above surface of hollow	Thermocouple - Type T
EM2_Hummock_plus_15cm	Deg C	Soil temperature	5 cm below surface of hummock, 15 cm above surface of hollow	Thermocouple - Type T
EM2_Hummock_plus_0cm	Deg C	Soil temperature	20 cm below surface of hummock, same as surface of hollow	Thermocouple - Type T
EM2_Hummock20cm	Deg C	Soil temperature	40 cm below surface of hummock, 20 cm below surface of hollow	Thermocouple - Type T
EM2_Hummock60cm	Deg C	Soil temperature	80 cm below surface of hummock, 60 cm below surface of hollow	Thermocouple - Type T
EM2_Hummock140cm	Deg C	Soil temperature	160 cm below surface of hummock, 140 cm below surface of hollow	Thermocouple - Type T
EM2_Hummock180cm	Deg C	Soil temperature	200 cm below surface of hummock, 180 cm below surface of hollow	Thermocouple - Type T
EM3_HollowSurf	Deg C	Soil temperature	Surface of hollow	Thermocouple - Type T
EM3_Hollow5cm	Deg C	Soil temperature	5 cm below surface of hollow	Thermocouple - Type T
EM3_Hollow20cm	Deg C	Soil temperature	20 cm below surface of hollow	Thermocouple - Type T
EM3_Hollow40cm	Deg C	Soil temperature	40 cm below surface of hollow	Thermocouple - Type T
EM3_Hollow80cm	Deg C	Soil temperature	80 cm below surface of hollow	Thermocouple - Type T
EM3_Hollow160cm	Deg C	Soil temperature	160 cm below surface of hollow	Thermocouple - Type T

Column Headings	Units or Format	Name Description	Sensor Position	Sensor Description
EM3_Hollow200cm	Deg C	Soil temperature	200 cm below surface of hollow	Thermocouple - Type T
EM3_Hummock_plus_40cm	Deg C	Soil temperature	Hummock surface, 40 cm above surface of hollow	Thermocouple - Type T
EM3_Hummock_plus_35cm	Deg C	Soil temperature	5 cm below surface of hummock, 35 cm above surface of hollow	Thermocouple - Type T
EM3_Hummock_plus_20cm	Deg C	Soil temperature	20 cm below surface of hummock, 20 cm above surface of hollow	Thermocouple - Type T
EM3_Hummock0cm	Deg C	Soil temperature	40 cm below surface of hummock, is surface of hollow	Thermocouple - Type T
EM3_Hummock40cm	Deg C	Soil temperature	80 cm below surface of hummock, 40 cm below surface of hollow	Thermocouple - Type T
EM3_Hummock120cm	Deg C	Soil temperature	160 cm below surface of hummock, 120 cm below surface of hollow	Thermocouple - Type T
EM3_Hummock160cm	Deg C	Soil temperature	200 cm below surface of hummock, 160 cm below surface of hollow	Thermocouple - Type T
EM1_PAR_2M	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	2 meters above ground level	Quantum Sensor - silicon photovoltaic detector
EM2_PAR_2M	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	2 meters above ground level	Quantum Sensor - silicon photovoltaic detector
EM3_PAR_2M	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	2 meters above ground level	Quantum Sensor - silicon photovoltaic detector
EM3_PAR_1M	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	1 meter above ground level	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_NTree1	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	North side of tree 1	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_NTree2	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	North side of tree 2	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_SouthofHollow1	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	South of hollow 1	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_SouthofHollow2	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	South of hollow 2	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_NorthofHollow1	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	North of hollow 1	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_NorthofHollow2	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	North of hollow 2	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_Srub1	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	Under shrub 1	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_Srub2	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	Under shrub 2	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_Srub3	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	Under shrub 3	Quantum Sensor - silicon photovoltaic detector
EM1_PAR_Srub4	umol s-1 m-2	Photosynthetically active radiation (PAR, 400-700 nm)	Under shrub 4	Quantum Sensor - silicon photovoltaic detector
EM1_VW1_TopofHummock	VWC	Volumetric water content	Top of hummock	Measures dielectric constant of the media using capacitance/frequency domain technology.

Column Headings	Units or Format	Name Description	Sensor Position	Sensor Description
EM1_VW2_MidofHummock	VWC	Volumetric water content	Middle of hummock	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM1_VW3_Surface1	VWC	Volumetric water content	Surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM1_VW4_Surface2	VWC	Volumetric water content	Surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM1_VW5_D1_20cm	VWC	Volumetric water content	20 cm below surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM1_VW6_D2_20cm	VWC	Volumetric water content	20 cm below surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM3_VW_1_TopofHummock	VWC	Volumetric water content	Top of hummock	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM3_VW_2_MidofHummock	VWC	Volumetric water content	Middle of hummock	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM3_VW_3_Surface1	VWC	Volumetric water content	Surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM3_VW_4_Surface2	VWC	Volumetric water content	Surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM3_VW_5_D1_20cm	VWC	Volumetric water content	20 cm below surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM3_VW_6_D2_20cm	VWC	Volumetric water content	20 cm below surface of hollow	Measures dielectric constant of the media using capacitance/frequency domain technology.
EM1_short_up	W/m^2	Shortwave downwelling irradiance (300-2800 nm)	2 meters above ground level. Sensor facing up.	Pyranometer
EM1_short_dn	W/m^2	Shortwave upwelling irradiance (300-2800 nm)	2 meters above ground level. Sensor facing down.	Pyranometer
EM1_long_up_corr	W/m^2	Longwave downwelling irradiance (4500-42000 nm), temperature corrected	2 meters above ground level. Sensor facing up.	Pyrgeometer
EM1_long_dn_corr	W/m^2	Longwave upwelling irradiance (4500-42000 nm), temperature corrected	2 meters above ground level. Sensor facing down.	Pyrgeometer
EM1_Rs_net	W/m^2	Shortwave net radiation (300-2800 nm)	2 meters above ground level	Net radiometer
EM1_Rl_net	W/m^2	Longwave net radiation (4500-42000 nm)	2 meters above ground level	Net radiometer
EM1_albedo	W/m^2	Albedo	2 meters above ground level	Net radiometer
EM1_Rn	W/m^2	Net radiation	2 meters above ground level	Net radiometer

Column Headings	Units or Format	Name Description	Sensor Position	Sensor Description
EM1_Water_Level	mm	Groundwater level	Relative to surface of hollow at EM1. Negative value is below surface and a positive value is above surface of hollow.	Capacitive
EM1_Water_Temp	Deg C	Groundwater temperature	1.5 m below surface of hollow	Thermistor
EM2_Water_Level	mm	Groundwater level	Relative to surface of hollow at EM2. Negative value is below surface and a positive value is above surface of hollow.	Capacitive
EM2_Water_Temp	Deg C	Groundwater temperature	1.5 m below surface of hollow	Thermistor
EM3_Water_Level	mm	Groundwater level	Relative to surface of hollow at EM3. Negative value is below surface and a positive values is above surface of hollow.	Capacitive
EM3_Water_Temp	Deg C	Groundwater temperature	1.5 m below surface of hollow	Thermistor
EM1_File_name		Data collection file name for reference.		Data logger
EM1_Quality_level		Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures.		Assigned
EM2_File_name		Data collection file name for reference.		Data logger
EM2_Quality_level		Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures.		Assigned
EM3_File_name		Data collection file name for reference.		Data logger
EM3_Quality_level		Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures.		Assigned
datetime	yyyy-mm-ddThh:mm:ss	Timestamp at beginning of 30 minute measurement / averaging interval. Interval always begins at either hh:00 or hh:30. Time zone is CST. Format is8601dt 2010-06-19T14:30:00		Data logger
month	mm	Month of measurement		Data logger
day	dd	Day of measurement		Data logger
hour	hh	Hour of measurement		Data logger
minute	mm	Minute of measurement. Either 00 or 30.		Data logger

Example Data Records

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date,time,doy,dec_doy,cdoy,dec_cdoy,year,EM1_AirTC_2M,EM1_RH_2M,EM1_AirTCHumm,EM1_RH_Humm,EM1_BP_kPa,EM1_Rain_mm,
EM1_WS_ms_S,EM1_WindDir_D1,EM1_WindDir_SD1,EM1_Dewpoint,EM1_Dewpoint_Diff,EM2_AirTC_2M,EM2_RH_2M,EM2_AirTCHumm,
EM2_RH_Humm,EM2_BP_kPa,EM2_WS_ms_S,EM2_WindDir_D1,EM2_WindDir_SD1,EM3_AirTC_1M,EM3_RH_1M,EM3_AirTC_2M,
EM3_RH_2M,EM1_PAR_2M,EM2_PAR_2M,EM3_PAR_2M,EM3_PAR_1M,EM1_PAR_NTree1,EM1_PAR_NTree2,EM1_PAR_SouthofHollow1,
EM1_PAR_SouthofHollow2,EM1_PAR_NorthofHollow1,EM1_PAR_NorthofHollow2,EM1_PAR_Srub1,EM1_PAR_Srub2,EM1_PAR_Srub3,
EM1_PAR_Srub4,EM1_short_up,EM1_short_dn,EM1_long_up_corr,EM1_long_dn_corr,EM1_Rs_net,EM1_Rl_net,EM1_albedo,EM1_Rn,
EM1_HollowSurf,EM1_Hollow5cm,EM1_Hollow20cm,EM1_Hollow40cm,EM1_Hollow80cm,EM1_Hollow160cm,EM1_Hollow200cm,
EM1_Hummock_plus_30cm,EM1_Hummock_plus_25cm,EM1_Hummock_plus_10cm,EM1_Hummock10cm,EM1_Hummock50cm,
EM1_Hummock130cm,EM1_Hummock170cm,EM2_HollowSurf,EM2_Hollow5cm,EM2_Hollow20cm,EM2_Hollow40cm,EM2_Hollow80cm,
EM2_Hollow160cm,EM2_Hollow200cm,EM2_Hummock_plus_20cm,EM2_Hummock_plus_15cm,EM2_Hummock_plus_0cm,
EM2_Hummock20cm,EM2_Hummock60cm,EM2_Hummock140cm,EM2_Hummock180cm,EM3_HollowSurf,EM3_Hollow5cm,
EM3_Hollow20cm,EM3_Hollow40cm,EM3_Hollow80cm,EM3_Hollow160cm,EM3_Hollow200cm,EM3_Hummock_plus_40cm,
EM3_Hummock_plus_35cm,EM3_Hummock_plus_20cm,EM3_Hummock0cm,EM3_Hummock40cm,EM3_Hummock120cm,EM3_Hummock160cm,
EM1_Water_Level,EM2_Water_Level,EM3_Water_Level,EM1_Water_Temp,EM2_Water_Temp,EM3_Water_Temp,EM1_VW1_TopofHummock,
EM1_VW2_MidofHummock,EM1_VW3_Surface1,EM1_VW4_Surface2,EM1_VW5_D1_20cm,EM1_VW6_D2_20cm,EM3_VW_1_TopofHummock,
EM3_VW_2_MidofHummock,EM3_VW_3_Surface1,EM3_VW_4_Surface2,EM3_VW_5_D1_20cm,EM3_VW_6_D2_20cm,datetime,month,day,hour,
minute,EM1_Quality_level,EM2_Quality_level,EM3_Quality_level

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…
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11.39,9.72,9.78,6.259,3.884,4.13,7.844,6.643,6.534,5.108,3.302,3.641,4.145,9.32,8.54,7.688,7.045,4.055,3.04,3.552,-52,-41,-44,506.1,511.9,492.9,0.143,
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9999,-9999,-9999,6.167,5.991,6.696,8.17,9.69,9.2,8.49,9.8,8.64,6.135,6.432,8.85,9.7,9.12,4.973,4.75,5.558,7.173,8.93,8.56,7.815,7.939,7.137,5.124,
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Line breaks added for readability.
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3. Data Application and Derivation:

Measurements of the environmental conditions at these stations will serve as a pre-treatment baseline for experimental treatments, provide driver data for future modeling activities, and will continue to provide a long-term ambient meteorological and hydrological record for the S1 bog.

4. Quality Assessment:

These data are considered at **Quality Level 1**. Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures. Established calibration procedures were followed.

5. Data Acquisition Materials and Methods:

Station Locations:
There are three monitoring sites located in the S1 Bog: Stations 1 and 2 are co-located at the southern end of the bog and Station 3 is located in the north central portion. The stations are equipped with standard sensors for measuring meteorological parameters, solar radiation, soil temperature and moisture, and groundwater temperature and elevation. Note that some sensor locations are relative to nearby vegetation and bog microtopographic features (i.e., hollows and hummocks). Sensors and data loggers were installed and became operational in June, July, and August 2010.

Sensor Network:
SPRUCE uses Campbell Scientific data loggers, multiplexers, enclosures and a wide variety of sensors. The stations measure numerous factors of wind, solar radiation, air temperature and humidity, soil temperature and moisture at multiple depths, snow depth, precipitation, barometric pressure, and groundwater temperature and level. Phenology photographs are automatically taken.

None of the stations are on the electrical grid. The sites use 50-watt solar panels to charge deep cycle marine batteries. The batteries are housed in large coolers to help protect them from environmental conditions. Sensor wires and power cables are protected from gnawing animals by flexible conduit. Mounting posts are helical piles that have been screwed through the 2-3 meter peat layer until they are anchored in the soil layer below.

Figure 2. Station 1 (A) meteorological sensors and Campbell Scientific data logger configuration and (B) PAR sensor positioned adjacent to nearby shrubs.

Figure 3. Station 3 (A) 50-watt solar panel with deep cycle marine batteries contained in sealed cooler. All stations are power by a similar solar charging arrangement. (B) Groundwater height and temperature sensor positioned nearby.

Data Collection:
Measurements are made on a one minute interval and every thirty minutes are averaged or totaled as appropriate and recorded. Data files are collected manually each week. Each data logger uses a flash card memory as a data back-up. Phenology photographs are automatically taken twice a day with two cameras.

Calibration and Preventative Maintenance:
Calibration of sensors and preventative maintenance of sensors and the sensor network follow manufactures' recommendations. The sensors and other network components are tagged with unique identifiers and registered with the ORNL Facility Service Center (FCS) asset management system. The FCS maintains manufacturer information, tracks preventive maintenance and calibration schedules, stores results of calibrations, and notifies staff of upcoming tasks.

Data Processing:
Data files are downloaded weekly from the Campbell Scientific data loggers at each Station by US Forest Service Staff and forwarded to ORNL per our established data transfer protocol. Data files are read with station-specific SAS scripts, range checked, and time series plots produced to look for obvious outliers. Data are combined across stations by the common 30-minute reporting interval and exported as a comma separated (*.csv) ASCII file.

6. References:

Hanson PJ, Childs KW, Wullschleger SD, Riggs JS, Thomas WK, Todd DE, Warren JM (2011) A method for experimental heating of intact soil profiles for application to climate change experiments. Global Change Biology 17:1083-1096. DOI: 10.1111/j.1365-2486.2010.02221.x

7. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Carbon Dioxide Information Analysis Center (CDIAC)

Data Archive Center:

Contact for Data Center Access Information:

E-mail: http://cdiacservices.ornl.gov/feedback.cfm